Boschert Associates

Switching Power Supply

MODELS 60, 80, 150, 151, 152, 153, 300, AND 301

1389

boschert

SWITCHING POWER SUPPLY

MAINTENANCE MANUAL

MODELS OL 60, 80, 150, 151, 152, 153, 300 AND 301

BOSCHERT ASSOCIATES
384 Santa Trinita
Sunnyvale, CA 94086
(408) 732 - 2440

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_06234

PREFACE

THIS MAINTENANCE MANUAL AND ALL CIRCUIT SCHEMATICS SUPPLIED WITH THIS MANUAL ARE THE PROPERTY OF BOSCHERT ASSOCIATES AND SHALL NOT BE REPRODUCED OR COPIED OR USED IN WHOLE OR IN PART AS THE BASIS FOR MANUFACTURE OR SALE OF THE ITEMS SHOWN THEREIN WITHOUT THE EXPRESS WRITTEN PERMISSION OF AN OFFICER OF BOSCHERT ASSOCIATES.

THIS MANUAL AND THE ACCOMPANYING CIRCUIT SCHEMATICS ARE TO BE USED SOLELY TO MAINTAIN EQUIPMENT MANUFACTURED BY BOSCHERT ASSOCIATES.

3. OUT OF WARRANTY REPAIR CHARGES: The following table outlines the fixed rate repair charges for repairs after the warranty period. BOSCHERT ASSOCIATES reserves the right to refuse repair on any unit which in our estimation is beyond repair.

CHARGES

UNIT	PRICE
OL60	$30.00
OL80	$45.00
OL150/151/153	$55.00
OL300/301	$75.00

NOTE: PRICES SUBJECT TO PERIODIC REVISION

1. GENERAL DESCRIPTION

The BOSCHERT line of switching regulated power supplies have multiple outputs (from 3 to 6 distinct outputs), feature open frame construction. They are generally powered from A.C. sources with a nominal voltage of either 115 or 230 volts (only under rare circumstances may they be powered by both 115 or 230 volts; consult data sheet). Within certain limits they may also be powered from D.C. power sources (consult factory). Additional standard features include short circuit protection, over-voltage protection, light weight (typically 10% of the weight of linears), small size (typically 25% the size of linears), and high efficiency (typically they dissipate 20% of the power of linears).

Although each model in the BOSCHERT line of switching regulated power supplies is unique in design and construction, the underlying technology is identical for all power supplies listed on the front cover.

2. GENERAL SPECIFICATIONS

The general specifications to which BOSCHERT power supplies conform is as stated in Table 2-1 along with notes 2-1 and 2-2.

Table 2-1

SPECIFICATIONS

Input	100-130Vac 40-440Hz (200-260Vac available on some models).
Line Regulation 100-130Vac	±0.2%
Load Regulation 5 to 1 load current change on all outputs	+5V output: ±0.5% Other outputs: ±2% to ±5% depending on the load change.
Ripple and Spikes See figure 2-1 for test circuit	40mv RMS, 100mv peak-to-peak (typical).
Transient Response	0.5 milliseconds
Temperature Coefficient	0.01%/C^{o} (0.04%/C^{o}, OL60)
Protection	Fold back current limit, short circuit proof with automatic recovery, reverse voltage protection, over-voltage protection on all outputs.
Temperature Rating	-20^{o}C to +55^{o}C convection cool. 70^{o}C with forced air.
Efficiency	70-75%
Holdup 115V input	Will maintain regulation for 16 milliseconds after input power removal at full load.

Note 2-1: The load regulation specification assumes that all output currents exceed 300ma. Also, 1-2 amps (depending on the model) is required to keep the +5V output control loop operational.

Note 2-2: The noise test circuit is shown in Figure 2-1.

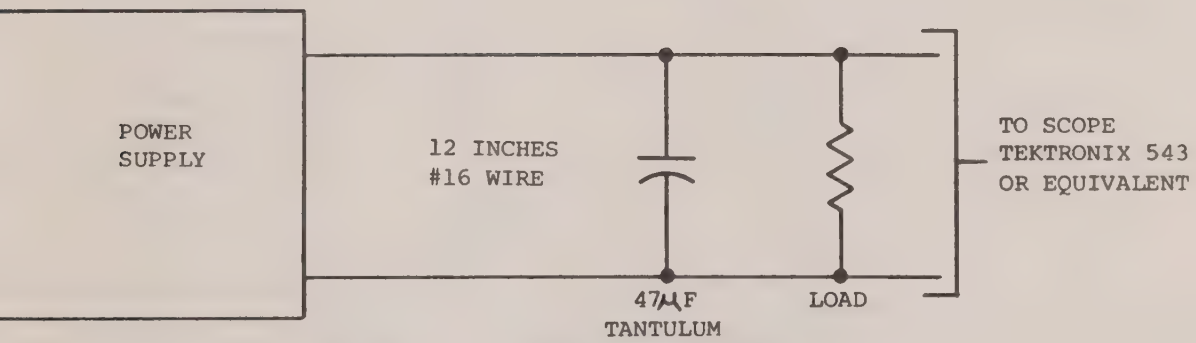


FIGURE 2-1 : NOISE TEST CIRCUIT

3. PRINCIPLES OF OPERATION

In order to understand the operation of the BOSCHERT line of switching regulated power supplies, the operating principle of a switching power supply and a D.C. to D.C. converter must first be understood by the reader.

3.1 An Elementary Switching Power Supply

The circuit of Figure 3-1 illustrates an elementary switching power supply.

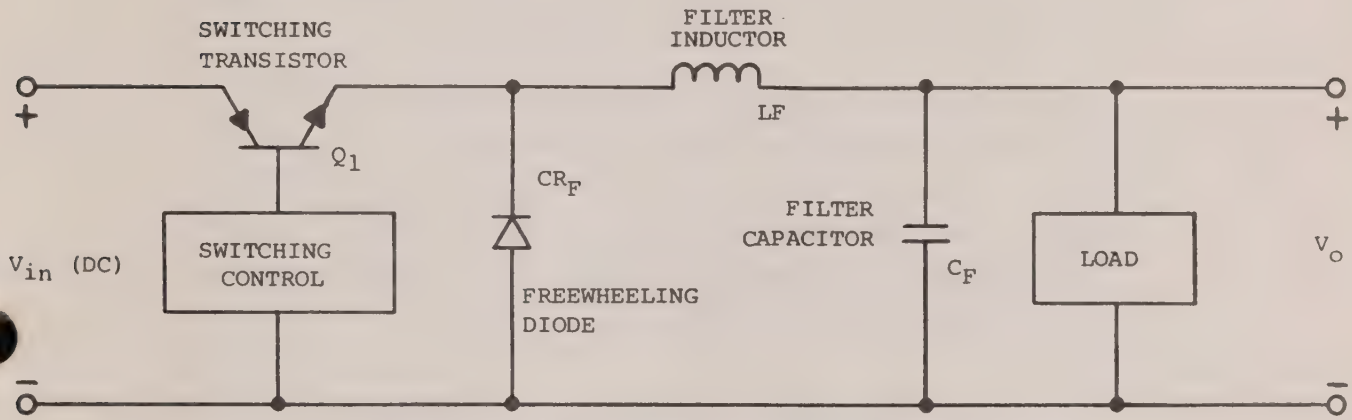


FIGURE 3-1 : AN ELEMENTARY SWITCHING POWER SUPPLY

The circuit consists of a D.C. power source at the input, a series pass switching transistor Q_1, a freewheeling diode CR_F, an output filter consisting of L_F and C_F and a load. The understanding of the circuit is facilitated by noting that an ideal inductor has no resistance, (therefore, no D.C. voltage appears across an ideal inductor), and no D.C. current flows through an ideal capacitor.

Since no D.C. current flows through the capacitor all D.C. current must flow through the load and the filter inductor. The average, or D.C. value of the output voltage, since no D.C. voltage drop appears across the inductor, is

the average voltage appearing at the emitter of transistor Q_1.

When transistor Q_1 is off, its emitter voltage is zero volts (assuming an ideal diode) and when transistor Q_1 is "on" its emitter voltage is V_{in} (assume an ideal switch). Therefore, the average voltage at the emitter of Q_1 obeys the following equation.

$$V_o(D.C.) = V_i \frac{T_{on}}{T_{on} + T_{off}}$$

Where T_{on} is the length of time that Q_1 is "on" and T_{off} is the length of time that Q_1 is "off".

This predicted behavior only occurs if transistor Q_1 is switched at a rate that greatly exceeds the natural frequencies created by the output filter (L_F and C_F) and the load. Generally due to the limitations of modern technology and acoustical noise considerations the switching frequency is chosen to be 20kHz. The values of L_F and C_F are then chosen to achieve the desired ripple specifications.

3.2 An Elementary D.C. to D.C. Converter

An elementary D.C. to D.C. converter is illustrated in Figure 3-2.

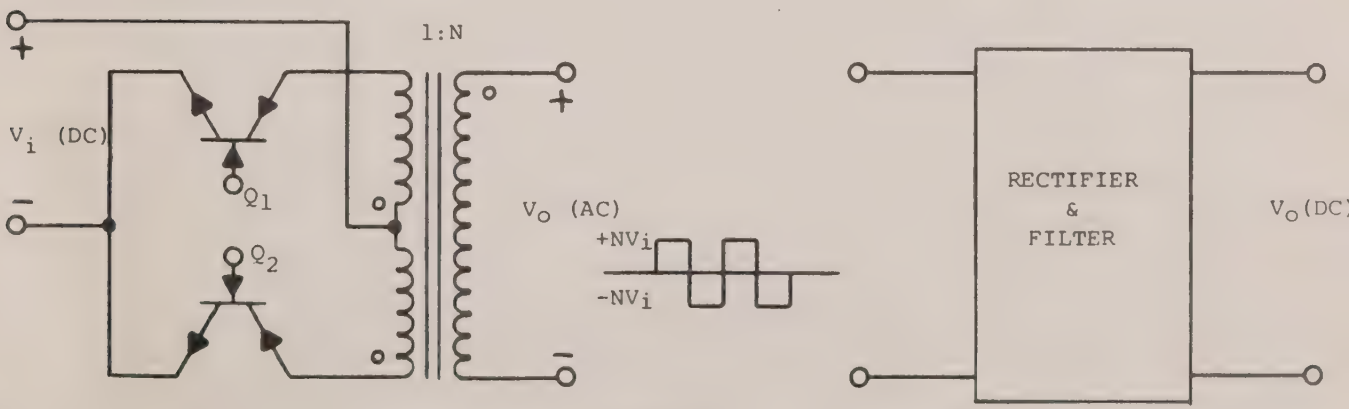


FIGURE 3-2 : AN ELEMENTARY D.C. TO D.C. CONVERTER

During normal operation (excluding switching transients) either transistor Q_1 or transistor Q_2 is saturated and hence, acting as a switch, while the other transistor is "off". If transistor Q_1 is on, and transistor Q_2 is off, assuming that the transformer core is not saturated, the output voltage $V_{o(A.C.)}$ behaves as follows:

$$V_{o(A.C.)} = N\ Vi$$

(N = number of turns)

If transistor Q_2 is "on" and transistor Q_1 is "off", then the output voltage behaves as follows:

$$V_{o(A.C.)} = -N\ V_i$$

As a result of the aforementioned switching operation the square wave output voltage shown at $V_{o(A.C.)}$ in Figure 3-2 is produced.

This output is converted to D.C. using either full-wave or half-wave rectifiers and a filter.

4. THE BOSCHERT SWITCHING REGULATED POWER SUPPLY

The BOSCHERT line of switching regulated power supplies is understood by considering the block diagram of Figure 4-1.

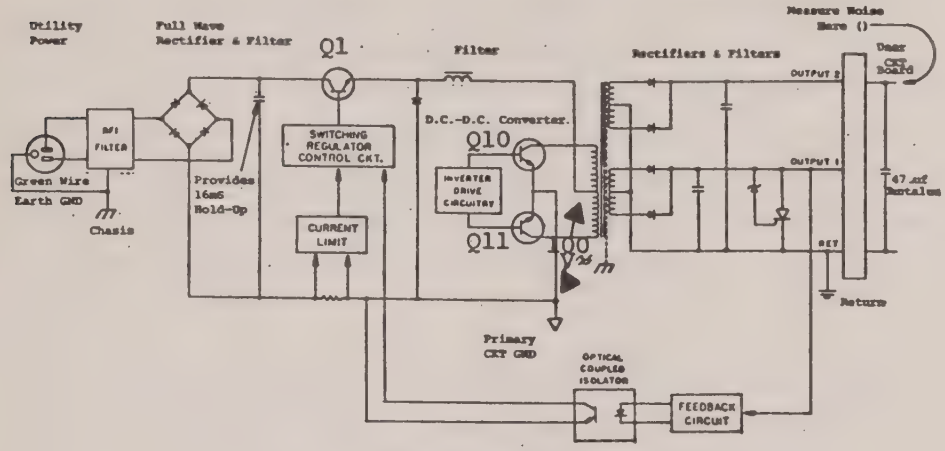


FIGURE 4-1

4.1 The Forward Path

The A.C. input consists of an RFI/EMI filter. This filter is used to prevent noise generated by transistor switching from being returned to the A.C. power mains.

The RFI/EMI filter is followed by a full-wave rectifier which charges the electrolytic capacitor to the peak value of the A.C. input voltage, i.e., $V_C = \sqrt{2}$ VA.C. The cathode of the electrolytic capacitor defines the primary circuit reference ground. (See sections 5.2 for a description of the various reference grounds).

The rectifiers are followed by the series pass transistor Q_1, a freewheeling diode, and a filter inductor. This circuitry provides a D.C. voltage approximately equal to 100 volts to the input of the converter stage (see section 3.1). The D.C. to D.C. converter produces the desired outputs from

this D.C. voltage. Multiple voltages are produced at the output through the use of multiple windings on the secondary of the converter transformer.

Overvoltage protection is provided by a "crowbar circuit" utilizing an SCR and a zener diode triggering circuit. When the output voltage on the principle output (normally the 5V output) exceeds the zener breakdown voltage, the SCR is fired and all outputs are crowbarred, since all outputs are related to each other by the converter transformer turns ratio . Therefore, all outputs are protected by this crowbar circuit on the principle output.

It should be noted that normally only one output voltage is directly fedback to the circuitry controlling the switching regulator. Regulation of the secondary output voltages is achieved by a control loop in the primary circuitry not shown in the diagram.

Current limiting is provided by sensing the voltage across a resistor in the primary circuit. If the output current becomes too excessive the input current must also be excessive and hence when the voltage across the sense resistor rises above the critcal value the switching control circuitry is turned "off".

4.2 The Feedback Path

The regulation of one output voltage is controlled by the feedback path. As the output voltage tries to increase/decrease, the feedback circuitry, which utilizes an opto-isolator, reduces/increases the time that transistor Q_1 is "on" during its switching cycle. This reduces/increases the input voltage to the D.C. to D.C. converter, (see sections 3.1 and 3.2). The effect of reducing/increasing the input voltage to the converter is to reduce/increase the output voltages.

5. INSTALLATION

The power supply arrives ready to connect and turn on. Refer to the data sheet for input and output voltage connections. The A.C. input voltage is also specified in the data sheet. The standard power supply is designed for use at 115 volts A.C. Certain power supplies are designed for 230 volt A.C. operation. In rare cases the power supply is designed to operate with 115 and 230 volt inputs. Please refer to data sheets to determine the required input to your particular supply.

5.1 Circuit Connections, Fuses, and Precautions

(1) The A.C. line should be fused with Littlefuse 3AG series fuses (or equivalent) rated at 6-1/4 amps for the OL300 series, 3 amps for the OL150 series, and 1-1/2 amps for the OL80 series.

(2) The load should be checked to ensure that the current rating of each output will not be exceeded.

(3) After connections are made to the connector or terminal block, as well as the fuses, the supply may be connected to the A.C. power line.

Note: Because of the open frame construction, high voltages are accessible in this power supply. Care must be taken in handling the supply; DO NOT touch any part of the inside electronics or mechanical components. HANDLE ONLY BY THE "L BRACKET FRAME".

To prevent damage to the supply, A.C. power should be removed before disconnecting any of the various inputs or outputs.

5.2 Voltage Reference Grounds, Voltage Isolation and the Use of Electrical Test Equipment

In the BOSCHERT power supply there exists three "grounds" which may be understood through Figure 5-2 and discussion. The utility input power is provided using three wires. Two wires provide the A.C. voltage and the third wire (green) is connected to the earth ground at the building power distribution box. The green wire is attached to the chassis of the BOSCHERT power supply.

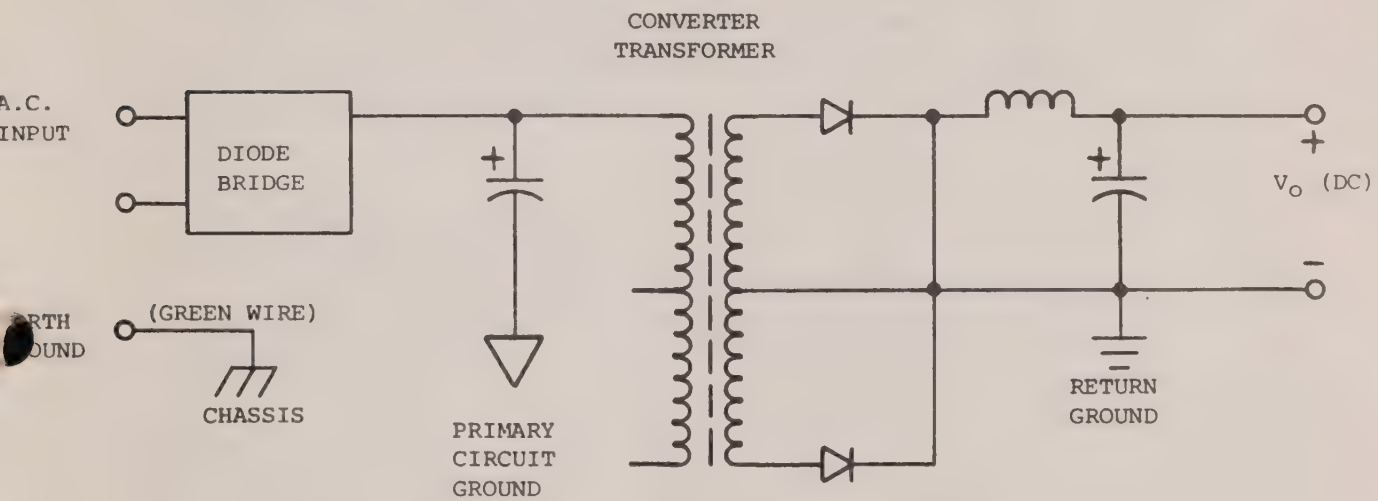


FIGURE 5–2 : GROUNDING ILLUSTRATION

After A.C. voltage enters the power supply it is rectified by a diode bridge and charges an electrolytic capacitor. The cathode of this capacitor defines the internal primary-circuit ground. The potential of the circuit ground is different from the green wire ground potential. Therefore, when using an oscilloscope or other measuring equipment to measure voltage potentials, electrical isolation must be provided between the power supply and the equipment through the use of measuring equipment capable of making a floating measurement, or by applying power to the supply through an isolation transformer.

CAUTION: The primary ground is floating at line voltage; a shock hazard exists.

The third ground is defined by the secondary winding of the converter transformer. This ground is electrically isolated from the other two grounds by a minimum voltage of 1700 volts. This ground is called "RETURN" on our literature. If isolation is not required or desired, the return ground may be tied to chassis ground. However, in this situation ground loops can occur which may cause interference. Care must be taken to observe good grounding practice to prevent ground loop noise problems.

6. OPERATING INSTRUCTIONS

Under no circumstances remove or insert the power supply edge connector while A.C. power is being applied to the power supply.

7. CONTINUED MAINTENANCE

Inspection and cleaning of the Printed Circuit Board should be made periodically so as to prevent short circuits and faulty connections at the connector or terminal strip.

At this time the output voltage may also be adjusted by adjusting the potentiometer R_{40}. (Refer to section 5 and to the detailed circuit schematic).

8. CORRECTIVE MAINTENANCE

Although the BOSCHERT line of switching regulated power supplies has been designed for maximum reliability, occasional corrective maintenance may be required. Before any maintenance is attempted this manual MUST be read from cover to cover. In order to troubleshoot the supply the circuit schematic must be understood and all safety precautions regarding high voltage must be followed. Before connecting any test equipment to the BOSCHERT power supply review sections 5.1 and 5.2.

To maintain BOSCHERT switching power supplies effectively it is recommended that the following equipment be readily available.

(1) An Ohmmeter*
(2) A D.C. Voltmeter
(3) An Oscilloscope
(4) A load capable of drawing at least 300 ma from each output simultaneously.
(5) A Variac
(6) A 100Ω, 500 watt load resistor**

*Any testing of transistor, diodes, etc. in an attempt to locate a short or open circuit is best accomplished using an ohmmeter on the 10Ω scale. It should be noted that the ohmmeter may cause damage to solid state components if the breakdown voltages of junctions are exceeded.

**This resistor is used in certain tests that are described in the text of this section. If a lower power resistor is used the testing should be completed quickly so as not to overheat the resistor.

There are four possible modes of malfunctions of the power supplies. These include excessive output noise and/or ripple, improper output voltage levels, poor load regulation and the absence of any output voltage.

8.1 Excessive Output Noise and/or Ripple

If the power supply is exhibiting excessive noise spikes (greater than 200mv) and/or excessive ripple, but the output voltages appear to be correct, the problem is in the output section of the power supply.

(1) Ensure that at least a 300ma current is being delivered to the load at each output.
(2) Check the output diodes for failures (CR_{17}, CR_{18}, etc.).
(3) Check the output filter capacitors for failures (C_{18}, C_{19}, etc.).
(4) Check the capacitors placed directly across the output diodes.

8.2 Improper Output Voltage Levels

The first question to address is if all outputs are either too high or too low. If either of these situations occurs, adjust the potentiometer (R_{40}). If this adjustment fails to alleviate the problem then proceed to section 8.3.

8.3 Poor Load Regulation

Poor load regulation is usually caused by a failure in the feedback network. This type of failure is easily located through the following procedure.

(1) Check the voltage between pins 7 and 12 on A_2 (the

LM723 integrated circuit). This voltage should be between 11.5 and 15 volts. The supply voltage for A_2 is derived from one of the outputs via a resistor network.

(2) Connect pins 2 and 3 of A_2 together. If the output voltages rise then the problem is associated with A_2, if the output does not rise the failure is associated with A_3 (the opto-isolator). A non-zero voltage should appear across resistors R_{33} and R_{47} as well as between pins 4 and 5 of A_3, if A_3 is operating correctly.

(3) Check the output diodes CR_{17}, CR_{18}, etc. for failures or high dynamic impedance.

8.4 The Absence of any Output Voltage

The absence of any output voltage could occur because the protection circuitry is operational or because a circuit failure has occured.

If the overvoltage protection circuitry is operational, approximately 1.0 volt will appear from the cathode to anode and approximately .8 volt will appear from gate to cathode of SCR_1.

If the current limit circuit is operational a non-zero voltage will appear across resistor R_{20}. Check the output loading, the SCR overvoltage protection circuitry, as well as transistors Q_8 and Q_9.

If these tests fail to locate the problem it may be assumed that a failure has occurred in the switching regulator, the switching regulator control circuitry, or the D.C. to D.C. converter. As a preliminary investigation check the input

fuses and the full wave rectifier diodes at the power supply input. If the diodes and fuses have not failed, then using a variac to supply the input power, follow this procedure:

(1) Disconnect the forward current path between inductor L_3 and the transformer of the D.C. to D.C. converter. (A mechanical connection has been provided in order to do this).

(2) Connect a 100Ω, 500 watt resistor in the circuit at this point. This allows testing of the input circuitry in a controlled manner (see notes 1 and 2 below).

Note 1: The power rating of the resistor may be less than 500 watts but the testing must be done relatively quickly so as to prevent overheating of the resistor.

Note 2: The load resistor should be used in the majority of testing involved with the switching regulator and the D.C. to D.C. converter. Very frequently when one component fails another component may be overstressed and also fail. Therefore perform complete and thorough testing of the various components.

(3) Apply A.C. voltage by adjusting the variac. With full A.C. voltage applied at the input, a D.C. voltage equal to approximately 100 volts should appear across the resistor. If so, then the problem is associated with the overvoltage protection circuit, (check SCR_1 for failure), with the foldback current limit circuit (see item 7), or with the D.C. to D.C. converter switching transistors.

(4) Check the D.C. to D.C. converter switching transistors Q_{10} and Q_{11}. (Q_8 and Q_9 on some supplies). If 100 volts does not appear across the resistor then the failure is pro-

bably associated with the switching transistor Q_1, or its basedrive circuitry.

(5) Check transistor Q_1, Q_2, Q_3 and Q_4 for failures.

(6) Check the supply voltage to A_1 (the LM723 integrated circuit). The voltage between pins 7 and 12 should be greater than 11.5 and less than 15 volts. If not, check transistors Q_5, Q_6, Q_7 and zener diode CR_8.

(7) Check for a non-zero voltage across resistor R_{20} which implies that the current limit circuit is operational. If the current limit circuity is operational check the load, check SCR_1 for operation or failure, and check transistors Q_8 or Q_9 for failure.

(8) Check and possibly replace A_1, (the LM723 integrated circuit).

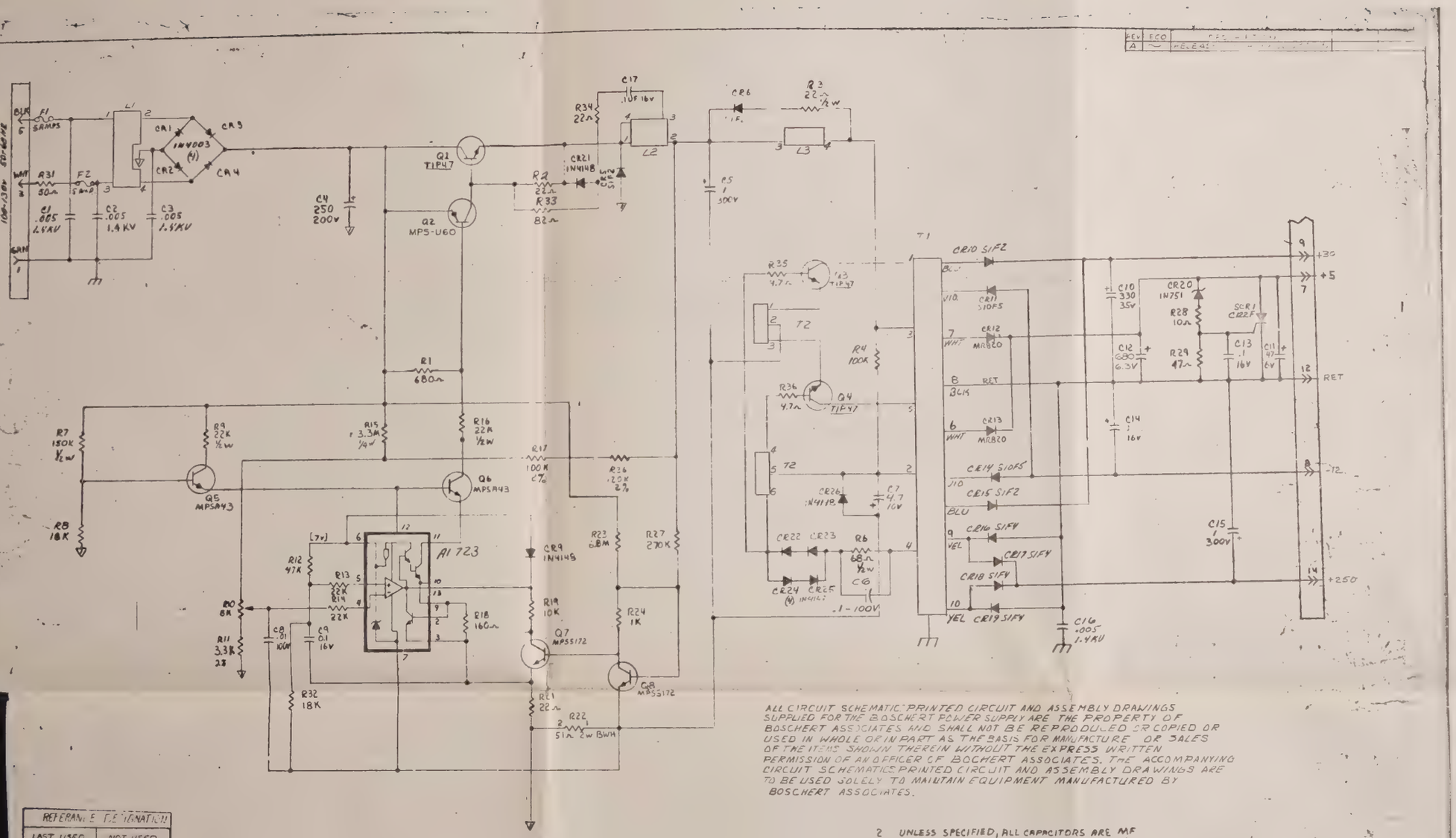
If the former test procedure fails to locate the problem then a thorough inspection should be made of all components, keeping in mind the possibility of bad solder connections. If the problem still fails to be discovered return the power supply to the factory for repair.

9. RECOMMENDED SPARE PARTS

In areas where it is inconvenient to return the power supplies to BOSCHERT ASSOCIATES for repair it is recommended that a number of spare parts be stocked. Listed in order of importance, they are:

(1) Spare fuses.
(2) Power transistors Q_1, Q_{10}, Q_{11} (the D.C. to D.C. converter switching transistors Q_8, Q_9 on some supplies).
(3) Signal transistors Q_2, Q_3, Q_4, Q_5, Q_6, Q_7, Q_8, Q_9.
(4) Output capacitors C_{18}, C_{19}, etc.
(5) Diodes CR_1, CR_2, CR_3, CR_4, CR_{18}, CR_{19}, etc,
(6) Integrated circuits A_1, A_2, and A_3.

Contact Boschert Associates for assistance in ordering spare parts.



ALL CIRCUIT SCHEMATICS PRINTED CIRCUIT AND ASSEMBLY DRAWINGS SUPPLIED FOR THE BOSCHERT POWER SUPPLY ARE THE PROPERTY OF BOSCHERT ASSOCIATES AND SHALL NOT BE REPRODUCED OR COPIED OR USED IN WHOLE OR IN PART AS THE BASIS FOR MANUFACTURE OR SALES OF THE ITEMS SHOWN THEREIN WITHOUT THE EXPRESS WRITTEN PERMISSION OF AN OFFICER OF BOSCHERT ASSOCIATES. THE ACCOMPANYING CIRCUIT SCHEMATICS PRINTED CIRCUIT AND ASSEMBLY DRAWINGS ARE TO BE USED SOLELY TO MAINTAIN EQUIPMENT MANUFACTURED BY BOSCHERT ASSOCIATES.

NOTES:
2 UNLESS SPECIFIED, ALL CAPACITORS ARE MF
1 UNLESS SPECIFIED, ALL RESISTORS ARE ¼W

REFERANCE DESIGNATION	
LAST USED	NOT USED
R36	R37, 38, 39
C17	
CR26	CR27, 28
L3	
T2	
A1	
SCR1	
F2	

USED ON
60-016

SCHEMATIC, 11
2.5 WATT
020

boschert

SWITCHING POWER SUPPLY

MAINTENANCE MANUAL

MODELS OL 60, 80, 150, 151, 152, 153, 300 AND 301

BOSCHERT ASSOCIATES
384 Santa Trinita
Sunnyvale, CA 94086
(408) 732 - 2440

PREFACE

THIS MAINTENANCE MANUAL AND ALL CIRCUIT SCHEMATICS SUPPLIED WITH THIS MANUAL ARE THE PROPERTY OF BOSCHERT ASSOCIATES AND SHALL NOT BE REPRODUCED OR COPIED OR USED IN WHOLE OR IN PART AS THE BASIS FOR MANUFACTURE OR SALE OF THE ITEMS SHOWN THEREIN WITHOUT THE EXPRESS WRITTEN PERMISSION OF AN OFFICER OF BOSCHERT ASSOCIATES.

THIS MANUAL AND THE ACCOMPANYING CIRCUIT SCHEMATICS ARE TO BE USED SOLELY TO MAINTAIN EQUIPMENT MANUFACTURED BY BOSCHERT ASSOCIATES.

3. OUT OF WARRANTY REPAIR CHARGES: The following table outlines the fixed rate repair charges for repairs after the warranty period. BOSCHERT ASSOCIATES reserves the right to refuse repair on any unit which in our estimation is beyond repair.

CHARGES

UNIT	PRICE
OL60	$30.00
OL80	$45.00
OL150/151/153	$55.00
OL300/301	$75.00

NOTE: PRICES SUBJECT TO PERIODIC REVISION

1. GENERAL DESCRIPTION

The BOSCHERT line of switching regulated power supplies have multiple outputs (from 3 to 6 distinct outputs), feature open frame construction. They are generally powered from A.C. sources with a nominal voltage of either 115 or 230 volts (only under rare circumstances may they be powered by both 115 or 230 volts; consult data sheet). Within certain limits they may also be powered from D.C. power sources (consult factory). Additional standard features include short circuit protection, over-voltage protection, light weight (typically 10% of the weight of linears), small size (typically 25% the size of linears), and high efficiency (typically they dissipate 20% of the power of linears).

Although each model in the BOSCHERT line of switching regulated power supplies is unique in design and construction, the underlying technology is identical for all power supplies listed on the front cover.

2. GENERAL SPECIFICATIONS

The general specifications to which BOSCHERT power supplies conform is as stated in Table 2-1 along with notes 2-1 and 2-2.

Table 2-1

SPECIFICATIONS

Input	100-130Vac 40-440Hz (200-260Vac available on some models).
Line Regulation 100-130Vac	±0.2%
Load Regulation 5 to 1 load current change on all outputs	+5V output: ±0.5% Other outputs: ±2% to ±5% depending on the load change.
Ripple and Spikes See figure 2-1 for test circuit	40mv RMS, 100mv peak-to-peak (typical).
Transient Response	0.5 milliseconds
Temperature Coefficient	0.01%/C° (0.04%/C°, OL60)
Protection	Fold back current limit, short circuit proof with automatic recovery, reverse voltage protection, over-voltage protection on all outputs.
Temperature Rating	-20°C to +55°C convection cool. 70°C with forced air.
Efficiency	70-75%
Holdup 115V input	Will maintain regulation for 16 milliseconds after input power removal at full load.

Note 2-1: The load regulation specification assumes that all output currents exceed 300ma. Also, 1-2 amps (depending on the model) is required to keep the +5V output control loop operational.

Note 2-2: The noise test circuit is shown in Figure 2-1.

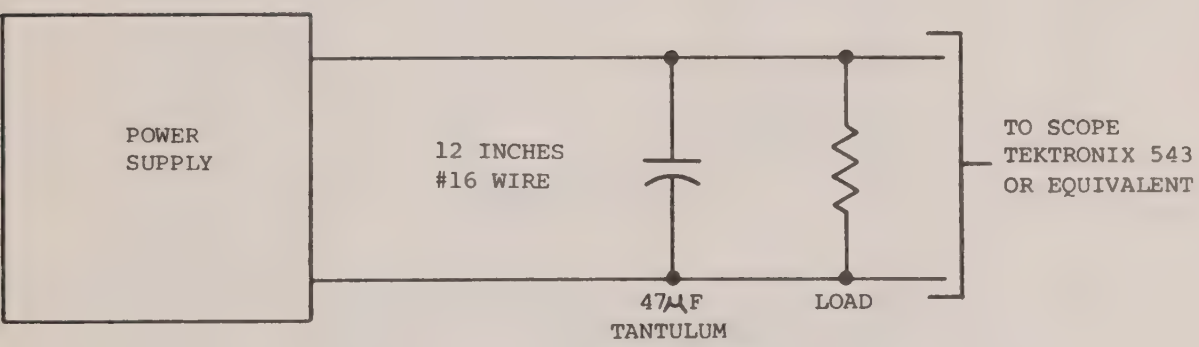


FIGURE 2-1 : NOISE TEST CIRCUIT

3. PRINCIPLES OF OPERATION

In order to understand the operation of the BOSCHERT line of switching regulated power supplies, the operating principle of a switching power supply and a D.C. to D.C. converter must first be understood by the reader.

3.1 An Elementary Switching Power Supply

The circuit of Figure 3-1 illustrates an elementary switching power supply.

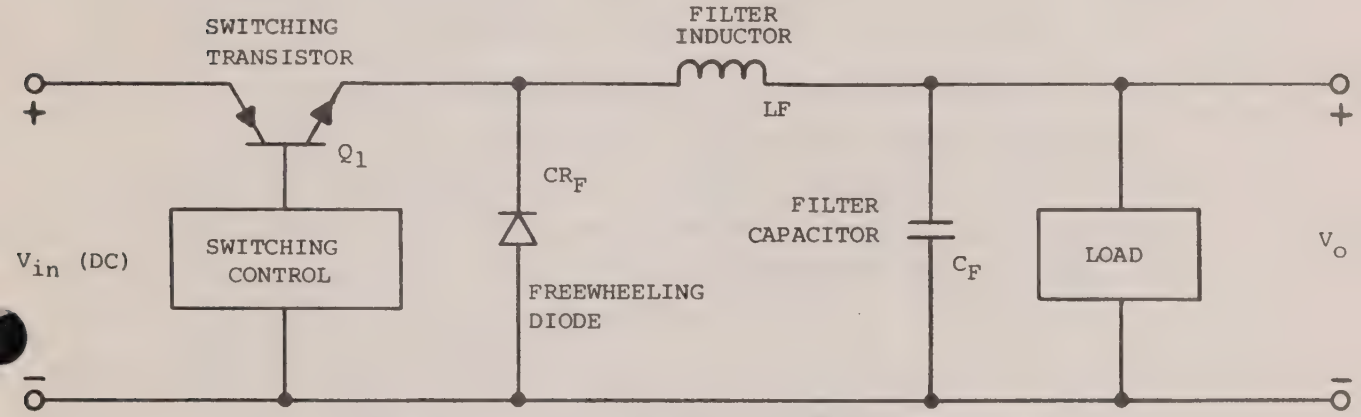


FIGURE 3-1 : AN ELEMENTARY SWITCHING POWER SUPPLY

The circuit consists of a D.C. power source at the input, a series pass switching transistor Q_1, a freewheeling diode CR_F, an output filter consisting of L_F and C_F and a load. The understanding of the circuit is facilitated by noting that an ideal inductor has no resistance, (therefore, no D.C. voltage appears across an ideal inductor), and no D.C. current flows through an ideal capacitor.

Since no D.C. current flows through the capacitor all D.C. current must flow through the load and the filter inductor. The average, or D.C. value of the output voltage, since no D.C. voltage drop appears across the inductor, is

the average voltage appearing at the emitter of transistor Q_1.

When transistor Q_1 is off, its emitter voltage is zero volts (assuming an ideal diode) and when transistor Q_1 is "on" its emitter voltage is V_{in} (assume an ideal switch). Therefore, the average voltage at the emitter of Q_1 obeys the following equation.

$$V_o(D.C.) = V_i \frac{T_{on}}{T_{on} + T_{off}}$$

Where T_{on} is the length of time that Q_1 is "on" and T_{off} is the length of time that Q_1 is "off".

This predicted behavior only occurs if transistor Q_1 is switched at a rate that greatly exceeds the natural frequencies created by the output filter (L_F and C_F) and the load. Generally due to the limitations of modern technology and acoustical noise considerations the switching frequency is chosen to be 20kHz. The values of L_F and C_F are then chosen to achieve the desired ripple specifications.

3.2 An Elementary D.C. to D.C. Converter

An elementary D.C. to D.C. converter is illustrated in Figure 3-2.

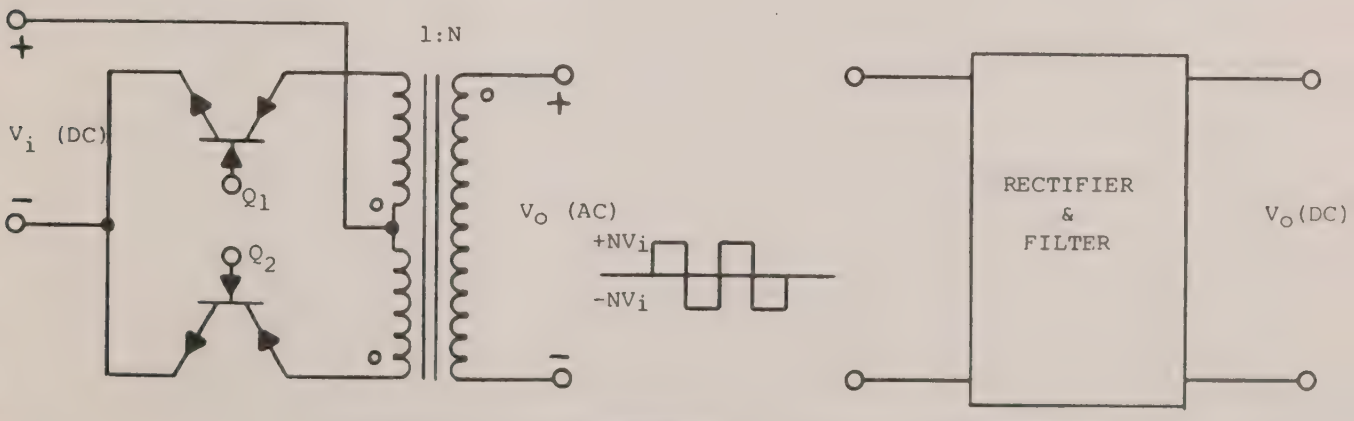


FIGURE 3-2 : AN ELEMENTARY D.C. TO D.C. CONVERTER

During normal operation (excluding switching transients) either transistor Q_1 or transistor Q_2 is saturated and hence, acting as a switch, while the other transistor is "off". If transistor Q_1 is on, and transistor Q_2 is off, assuming that the transformer core is not saturated, the output voltage $V_{o(A.C.)}$ behaves as follows:

$$V_{o(A.C.)} = N\ Vi$$

(N = number of turns)

If transistor Q_2 is "on" and transistor Q_1 is "off", then the output voltage behaves as follows:

$$V_{o(A.C.)} = -N\ V_i$$

As a result of the aforementioned switching operation the square wave output voltage shown at $V_{o(A.C.)}$ in Figure 3-2 is produced.

This output is converted to D.C. using either full-wave or half-wave rectifiers and a filter.

4. THE BOSCHERT SWITCHING REGULATED POWER SUPPLY

The BOSCHERT line of switching regulated power supplies is understood by considering the block diagram of Figure 4-1.

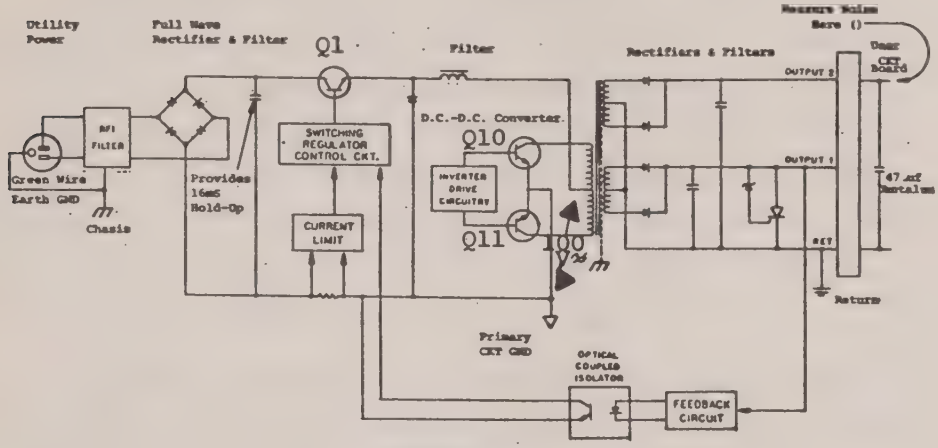


FIGURE 4-1

4.1 The Forward Path

The A.C. input consists of an RFI/EMI filter. This filter is used to prevent noise generated by transistor switching from being returned to the A.C. power mains.

The RFI/EMI filter is followed by a full-wave rectifier which charges the electrolytic capacitor to the peak value of the A.C. input voltage, i.e., $V_C = \sqrt{2}$ VA.C. The cathode of the electrolytic capacitor defines the primary circuit reference ground. (See sections 5.2 for a description of the various reference grounds).

The rectifiers are followed by the series pass transistor Q_1, a freewheeling diode, and a filter inductor. This circuitry provides a D.C. voltage approximately equal to 100 volts to the input of the converter stage (see section 3.1). The D.C. to D.C. converter produces the desired outputs from

this D.C. voltage. Multiple voltages are produced at the output through the use of multiple windings on the secondary of the converter transformer.

Overvoltage protection is provided by a "crowbar circuit" utilizing an SCR and a zener diode triggering circuit. When the output voltage on the principle output (normally the 5V output) exceeds the zener breakdown voltage, the SCR is fired and all outputs are crowbarred, since all outputs are related to each other by the converter transformer turns ratio . Therefore, all outputs are protected by this crowbar circuit on the principle output.

It should be noted that normally only one output voltage is directly fedback to the circuitry controlling the switching regulator. Regulation of the secondary output voltages is achieved by a control loop in the primary circuitry not shown in the diagram.

Current limiting is provided by sensing the voltage across a resistor in the primary circuit. If the output current becomes too excessive the input current must also be excessive and hence when the voltage across the sense resistor rises above the critcal value the switching control circuitry is turned "off".

4.2 The Feedback Path

The regulation of one output voltage is controlled by the feedback path. As the output voltage tries to increase/decrease, the feedback circuitry, which utilizes an opto-isolator, reduces/increases the time that transistor Q_1 is "on" during its switching cycle. This reduces/increases the input voltage to the D.C. to D.C. converter, (see sections 3.1 and 3.2). The effect of reducing/increasing the input voltage to the converter is to reduce/increase the output voltages.

5. INSTALLATION

The power supply arrives ready to connect and turn on. Refer to the data sheet for input and output voltage connections. The A.C. input voltage is also specified in the data sheet. The standard power supply is designed for use at 115 volts A.C. Certain power supplies are designed for 230 volt A.C. operation. In rare cases the power supply is designed to operate with 115 and 230 volt inputs. Please refer to data sheets to determine the required input to your particular supply.

5.1 Circuit Connections, Fuses, and Precautions

(1) The A.C. line should be fused with Littlefuse 3AG series fuses (or equivalent) rated at 6-1/4 amps for the OL300 series, 3 amps for the OL150 series, and 1-1/2 amps for the OL80 series.

(2) The load should be checked to ensure that the current rating of each output will not be exceeded.

(3) After connections are made to the connector or terminal block, as well as the fuses, the supply may be connected to the A.C. power line.

Note: Because of the open frame construction, high voltages are accessible in this power supply. Care must be taken in handling the supply; DO NOT touch any part of the inside electronics or mechanical components. HANDLE ONLY BY THE "L BRACKET FRAME".

To prevent damage to the supply, A.C. power should be removed before disconnecting any of the various inputs or outputs.

5.2 Voltage Reference Grounds, Voltage Isolation and the Use of Electrical Test Equipment

In the BOSCHERT power supply there exists three "grounds" which may be understood through Figure 5-2 and discussion. The utility input power is provided using three wires. Two wires provide the A.C. voltage and the third wire (green) is connected to the earth ground at the building power distribution box. The green wire is attached to the chassis of the BOSCHERT power supply.

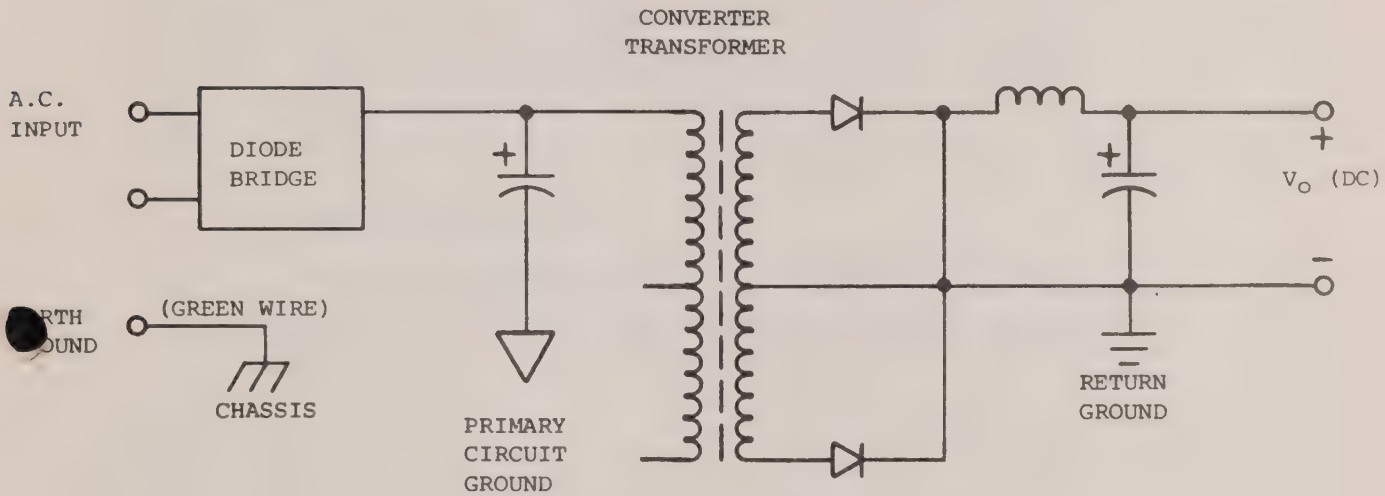


FIGURE 5–2 : GROUNDING ILLUSTRATION

After A.C. voltage enters the power supply it is rectified by a diode bridge and charges an electrolytic capacitor. The cathode of this capacitor defines the internal primary-circuit ground. The potential of the circuit ground is different from the green wire ground potential. Therefore, when using an oscilloscope or other measuring equipment to measure voltage potentials, electrical isolation must be provided between the power supply and the equipment through the use of measuring equipment capable of making a floating measurement, or by applying power to the supply through an isolation transformer.

CAUTION: The primary ground is floating at line voltage; a shock hazard exists.

The third ground is defined by the secondary winding of the converter transformer. This ground is electrically isolated from the other two grounds by a minimum voltage of 1700 volts. This ground is called "RETURN" on our literature. If isolation is not required or desired, the return ground may be tied to chassis ground. However, in this situation ground loops can occur which may cause interference. Care must be taken to observe good grounding practice to prevent ground loop noise problems.

6. OPERATING INSTRUCTIONS

Under no circumstances remove or insert the power supply edge connector while A.C. power is being applied to the power supply.

7. CONTINUED MAINTENANCE

Inspection and cleaning of the Printed Circuit Board should be made periodically so as to prevent short circuits and faulty connections at the connector or terminal strip.

At this time the output voltage may also be adjusted by adjusting the potentiometer R_{40}. (Refer to section 5 and to the detailed circuit schematic).

8. CORRECTIVE MAINTENANCE

Although the BOSCHERT line of switching regulated power supplies has been designed for maximum reliability, occasional corrective maintenance may be required. Before any maintenance is attempted this manual MUST be read from cover to cover. In order to troubleshoot the supply the circuit schematic must be understood and all safety precautions regarding high voltage must be followed. Before connecting any test equipment to the BOSCHERT power supply review sections 5.1 and 5.2.

To maintain BOSCHERT switching power supplies effectively it is recommended that the following equipment be readily available.

(1) An Ohmmeter*
(2) A D.C. Voltmeter
(3) An Oscilloscope
(4) A load capable of drawing at least 300 ma from each output simultaneously.
(5) A Variac
(6) A 100Ω, 500 watt load resistor**

*Any testing of transistor, diodes, etc. in an attempt to locate a short or open circuit is best accomplished using an ohmmeter on the 10Ω scale. It should be noted that the ohmmeter may cause damage to solid state components if the breakdown voltages of junctions are exceeded.

**This resistor is used in certain tests that are described in the text of this section. If a lower power resistor is used the testing should be completed quickly so as not to overheat the resistor.

There are four possible modes of malfunctions of the power supplies. These include excessive output noise and/or ripple, improper output voltage levels, poor load regulation and the absence of any output voltage.

8.1 Excessive Output Noise and/or Ripple

If the power supply is exhibiting excessive noise spikes (greater than 200mv) and/or excessive ripple, but the output voltages appear to be correct, the problem is in the output section of the power supply.

(1) Ensure that at least a 300ma current is being delivered to the load at each output.
(2) Check the output diodes for failures (CR_{17}, CR_{18}, etc.).
(3) Check the output filter capacitors for failures (C_{18}, C_{19}, etc.).
(4) Check the capacitors placed directly across the output diodes.

8.2 Improper Output Voltage Levels

The first question to address is if all outputs are either too high or too low. If either of these situations occurs, adjust the potentiometer (R_{40}). If this adjustment fails to alleviate the problem then proceed to section 8.3.

8.3 Poor Load Regulation

Poor load regulation is usually caused by a failure in the feedback network. This type of failure is easily located through the following procedure.

(1) Check the voltage between pins 7 and 12 on A_2 (the

LM723 integrated circuit). This voltage should be between 11.5 and 15 volts. The supply voltage for A_2 is derived from one of the outputs via a resistor network.

(2) Connect pins 2 and 3 of A_2 together. If the output voltages rise then the problem is associated with A_2, if the output does not rise the failure is associated with A_3 (the opto-isolator). A non-zero voltage should appear across resistors R_{33} and R_{47} as well as between pins 4 and 5 of A_3, if A_3 is operating correctly.

(3) Check the output diodes CR_{17}, CR_{18}, etc. for failures or high dynamic impedance.

8.4 The Absence of any Output Voltage

The absence of any output voltage could occur because the protection circuitry is operational or because a circuit failure has occured.

If the overvoltage protection circuitry is operational, approximately 1.0 volt will appear from the cathode to anode and approximately .8 volt will appear from gate to cathode of SCR_1.

If the current limit circuit is operational a non-zero voltage will appear across resistor R_{20}. Check the output loading, the SCR overvoltage protection circuitry, as well as transistors Q_8 and Q_9.

If these tests fail to locate the problem it may be assumed that a failure has occurred in the switching regulator, the switching regulator control circuitry, or the D.C. to D.C. converter. As a preliminary investigation check the input

fuses and the full wave rectifier diodes at the power supply input. If the diodes and fuses have not failed, then using a variac to supply the input power, follow this procedure:

(1) Disconnect the forward current path between inductor L_3 and the transformer of the D.C. to D.C. converter. (A mechanical connection has been provided in order to do this).

(2) Connect a 100Ω, 500 watt resistor in the circuit at this point. This allows testing of the input circuitry in a controlled manner (see notes 1 and 2 below).

Note 1: The power rating of the resistor may be less than 500 watts but the testing must be done relatively quickly so as to prevent overheating of the resistor.

Note 2: The load resistor should be used in the majority of testing involved with the switching regulator and the D.C. to D.C. converter. Very frequently when one component fails another component may be overstressed and also fail. Therefore perform complete and thorough testing of the various components.

(3) Apply A.C. voltage by adjusting the variac. With full A.C. voltage applied at the input, a D.C. voltage equal to approximately 100 volts should appear across the resistor. If so, then the problem is associated with the overvoltage protection circuit, (check SCR_1 for failure), with the foldback current limit circuit (see item 7), or with the D.C. to D.C. converter switching transistors.

(4) Check the D.C. to D.C. converter switching transistors Q_{10} and Q_{11}. (Q_8 and Q_9 on some supplies). If 100 volts does not appear across the resistor then the failure is pro-

bably associated with the switching transistor Q_1, or its basedrive circuitry.

(5) Check transistor Q_1, Q_2, Q_3 and Q_4 for failures.

(6) Check the supply voltage to A_1 (the LM723 integrated circuit). The voltage between pins 7 and 12 should be greater than 11.5 and less than 15 volts. If not, check transistors Q_5, Q_6, Q_7 and zener diode CR_8.

(7) Check for a non-zero voltage across resistor R_{20} which implies that the current limit circuit is operational. If the current limit circuity is operational check the load, check SCR_1 for operation or failure, and check transistors Q_8 or Q_9 for failure.

(8) Check and possibly replace A_1, (the LM723 integrated circuit).

If the former test procedure fails to locate the problem then a thorough inspection should be made of all components, keeping in mind the possibility of bad solder connections. If the problem still fails to be discovered return the power supply to the factory for repair.

9. RECOMMENDED SPARE PARTS

In areas where it is inconvenient to return the power supplies to BOSCHERT ASSOCIATES for repair it is recommended that a number of spare parts be stocked. Listed in order of importance, they are:

(1) Spare fuses.

(2) Power transistors Q_1, Q_{10}, Q_{11} (the D.C. to D.C. converter switching transistors Q_8, Q_9 on some supplies).

(3) Signal transistors Q_2, Q_3, Q_4, Q_5, Q_6, Q_7, Q_8, Q_9.

(4) Output capacitors C_{18}, C_{19}, etc.

(5) Diodes CR_1, CR_2, CR_3, CR_4, CR_{18}, CR_{19}, etc,

(6) Integrated circuits A_1, A_2, and A_3.

Contact Boschert Associates for assistance in ordering spare parts.

0 74070 15853 3

DUO-TANG
5125
MADE IN U.S.A.